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EDITORIAL.

WIDESPREAD interest has been aroused by the debate on the subject of Payment by Results, which was introduced by the President. A report of the introduction to the debate is published in this issue of the Journal, and the discussion will appear in the April issue.

The consensus of opinion seems to be that whatever system of payment be adopted, the main requirement is to engender confidence in the worker that if he produces to the limit of his capacity he will receive a square deal. There is, however, another aspect of the matter which was not so strongly emphasised, namely, that with the relatively small outputs prevailing in this country, flexibility is a most necessary feature of any system which is put into operation.

To cater for the widely differing abilities of individuals is, of course, in direct opposition to the policy of collective bargaining adopted by the Trade Unions. It is obviously impossible to raise the general standard of efficiency to the level of the fastest and most skilful worker, and it is equally absurd to attempt to obtain uniformity by restricting the activities of a really efficient workman to the pace set by his workmates. There are men who, however much they exert themselves, can never rise above mediocrity, but there are others whose low level of efficiency is entirely due to their own lack of effort, men who have the capacity but will not use it. In the case of the latter it is not in any way unfair if they are penalised by the system of payment adopted. Allowance must be made for varied conditions if we are to compete successfully in foreign markets.

PAYMENT BY RESULTS.

Introduction to a Debate by the President, Mr. R. H. Hutchinson.

WHEN starting to put down a few notes with which to open this debate this evening, it was brought home to me that the subject chosen, that of " Payment by Results," opened up a very vast field for conjecture and discussion. I also realised that the subject was one that would provide very ample material for a paper of some considerable length if one attempted to give expression in detail to all of the many lines of thought which it awakens. But I am not here this evening to read a paper, but merely to open a discussion, and therefore I have contented myself with an endeavour to set down just those points, from a discussion on which we are likely to derive the greatest use in the short time at our disposal this evening.

Now, obviously, in reviewing a subject of this nature, one has to regard it, not from the point of view of any particular class, but in its effect upon the community as a whole, which in this case is the bearing that it has upon the general industrial conditions prevailing to-day, and this being so one of the first things to consider is the effect of Payment by Results upon the relationship between master and man.

Now, probably the most pressing need at the present time for the recovery and advancement of industry, not only in this country but throughout the civilised world, is the introduction of a sound and proper understanding between what is generally, though perhaps somewhat inadequately phrased, Employers and Labour.

Inadequate, because in these days when individual employers have practically ceased to exist, or at any rate to count, and when labour, that is organised labour, is employed almost entirely by large industrial corporations and limited companies, the terms have become somewhat abstract, and it is no easy matter to define exactly where the term employer ceases to apply and where labour starts.

Broadly speaking, we can say that the employers are those who purchase from labour the results of their manual toil, and this being so we have to include under the heading "Employer " all who are in any way connected with this purchasing process, which, of course, includes managers, superintendents, and foremen.

Now, ask any workman in a large factory, preferably one of the agitating type—and they are not very difficult to find in these

days—to whom he refers when he talks about the employers, and invariably his reply will be " The Boss" Ask him who he means by " The Boss," and in most cases he " won't exactly know," or he will mention the name of one or other of the high officials of the firm for which he works, who in all probability has little or nothing to do with his particular grouse, but who is controlled entirely by circumstances or instructions from another source.

Talk to the average foreman, the man who is in actual and certainly closer touch than anyone else with labour, and try and find out what are his views of his own position in respect of the relations between employers and labour, and here again you will find that his ideas are quite indefinite on the subject. The thought that he can improve those relations by actively supporting and associating himself with his employer's policy and explaining it to his men is quite foreign to him, and only too often his principal object seems to be to keep on the right side of his men, or at any rate to keep out of any disputes that may occur. At the same time, should occasion arise when he has to report to his employers upon any shop conditions, he is constrained from putting the men's case forward fairly, as he sees it, for fear of giving the impression that he is too sympathetic towards them, and so unconsciously he hunts with the hounds and runs with the hare, because he doesn't realise that in actual fact he himself is an employer in regard to labour; and frequently I fear he is not given that support and recognition by his employers to encourage him to do so.

Such are the normal conditions of mind of the two classes of men who are really influencing the trend of thought between the two great sides of industry to-day—on the one hand, the workmen who because he has discovered, or thinks he has, that he can talk a bit, and because of the power that he unfortunately finds it gives to him, becomes a shop agitator, constantly pouring out his distorted and insidious doctrines, all the time sowing dissension between his fellow-workers and the " Boss," the imaginary person who, he preaches, from sheer love of oppression, is responsible for all the empirical wrongs that the workers suffer and who sits in his luxurious apartment thinking and scheming out ways and means of heaping still further sufferings and injustices upon them.

On the other hand, the one man more capable and in a better position than all others to combat this, we find sitting on the fence because neither he nor his employers realise it—and it is under conditions such as these that it is hoped to bring about that supreme essential of a better understanding between so-called employers and labour. In these days of keen world competition, when markets are none too good and when the exchanges of foreign countries are in the balance against us, and with those in our

midst whose avowed intention it is to stir up strife amongst our workers, more than at any previous time in the industrial history of our country does it behove all those who are in any way in charge of labour, or who have any power to influence them, to do everything in their power to bring to the minds of the workers of this country a better understanding of the grave, the tremendous, responsibility that rests on them individually and collectively to go all out and to produce to their utmost capacity the product, whatever it may be, that they are called upon to handle. At the same time, one cannot expect the worker to be more highly imbued with philanthropic notions than his employers, and it is only fair if one looks to him to work to his utmost that he should be paid in accordance with the results of his labours.

Now the inborn—the inherent—cupidity of every man, whether he be great or small, who has something to sell, results in a perfectly natural desire on his part to obtain the very best possible price for the smallest amount of the commodity of which he has to dispose. He would be a very unnatural man if he didn't. On the other hand, it is equally natural for the purchaser of the commodity to endeavour to get the largest possible amount for the smallest possible expenditure of money. He also would be an unnatural man if he didn't. And so, under the ordinary laws of supply and demand, an economic price level is arrived at for each and every commodity dealt in. If the demand is great the price will rise, production will automatically increase and adjust the price back to the economic level. But supposing that, due to some exterior controlling factor, production does not increase with demand, what do we invariably find? We find that the ingenuity of man has provided a substitute. One cannot conceive a manufacturer who would, in face of a rising demand, deliberately restrict his output with a mistaken idea of keeping up prices. Equally difficult would it be to picture one who, in the face of competition, would not endeavour by improved methods and increased production, to produce more at a lower cost so as to enable him to meet such competition, and at the same time to foster the demand for his commodity.

As I have already pointed out, the employers are those who purchase from the worker the results of his manual labour, in other words the employer is the buyer who is trying to get as much as he can for the smallest expenditure of money, and the worker is the seller who is trying to get as much money as he can for the smallest amount of work, and the economic price level arrived at in this case is the worker's rate of pay.

Now, if this was all that had to be considered, we should have little or no misunderstanding between employers and men.

If Labour would honestly go all out to produce to its utmost then the employer could afford to fix good prices all round for

his work, and the average wage earnings of the worker would, without doubt, even in these days of, comparatively speaking, bad trade, earn very much more than he does.

But unfortunately we do find in this case that exterior controlling factor, to which I have referred, and that is the deliberate restriction of output by the worker of to-day.

Whether this is the result of the persistent and insidious work of the minority movement, or due to the influence of the Trade Unions upon the mind of the average worker, it is almost impossible to determine, but the deplorable fact remains that, amongst the majority of workers in most of our factories, there is a very real and very deliberate cutting down of output regularly practised.

One thing is quite clear, and that is that it is very much more apparent in the strong Union shop than in those factories where the trade union influence is weak and in a few works which are entirely non-union it practically does not exist.

Now, in practising this the individual worker does not necessarily restrict the actual number of pieces turned out irrespective of price. He controls his output solely by the money he earns, keeping it down to a level that will bring his wages to a maximum of from time-and-a-third to time-and-a-half. No matter how quick or efficient a worker may be—no matter how much he could turn out above the average—he does not dare to go all out if it would result in his earning more than this amount.

The direct result of this is that the employer is forced in self-defence to keep his rates low in order to get a sufficient return from his machines, whereas it would frequently pay him better to give a higher rate on a job and allow his men to earn considerably more money in return for a higher machine-hour output.

Now, the only possible cause for this must be the existence of a grave misunderstanding between the men and their employers. Once remove this, and leave the way open for the worker to go all out to produce his utmost, in return for which allow him to earn all he can get on account of his superior skill and efficiency, and without any possible doubt production would increase enormously; the worker would be infinitely better off, and at the same time we should be considerably helped in our task of successfully competing in the markets of the world.

The questions that we arrive at, therefore, are:—

(1) What effect has the general principle of payment by results upon the relationship existing between employers and labour?

(2) What system of payment by results is most likely to promote a proper understanding between the parties concerned?

(3) What steps can be taken to give labour the necessary incentive to work and the confidence to enable the individual to go all out to produce to his utmost capacity?

(4) What protection can be given to the slower, though otherwise perfectly honest and good worker, who, though doing his best cannot attain the speed of his more efficient fellow worker?

I do not propose to attempt to answer these questions myself, as they are the main points which I hope you will debate shortly, but I think I might enlarge somewhat upon them, and I will therefore take them *seriatim*.

(1) The effect of the principle of payment by results upon the relationship existing between employers and labour.

Now, I do not think there are any people who do not agree that the only just and reasonable method of payment for productive labour is one that enables the worker to earn a wage in some manner proportionate to the amount of work produced.

In order to do this it is necessary to fix some sort of basis price for each piece operated upon, and the fixing of this automatically promotes a sense of barter in the minds of the parties concerned. Human nature is such that where such a sense exists it is always accompanied by a certain instinctive feeling of mistrust, a feeling no doubt so tiny that it is hardly recognised, but nevertheless always there—a spark perhaps—but a spark that is ever ready to be fanned into a mighty flame upon the slightest provocation and ever likely to cause ill-feeling between man and master.

For this reason it is a very essential thing that all questions affecting the fixing of rates, and still more the alterations of rates, should be conducted with scrupulous care and straightforwardness.

The individual representative of the employer most concerned in this is, of course, the rate-fixer, and for this reason too much care cannot be taken in the selection of such an important factor in the organisation.

The qualifications which it is necessary for him to have are :—

Infinite tact and firmness combined with a very considerable confidence in himself, but at the same time he must not in any way be bigoted. He must be a stickler for detail and accuracy, with a sound practical knowledge in the use of tools and able to demonstrate his times.

At the same time he must possess a correct knowledge of feeds and speeds for all kinds of machining operations and classes of material, and, above all, he must be able to command the respect and confidence of the workers.

In a shop where any system of payment by results is in force, the greatest care should be taken in the organisation of those sections directly affecting the capacity of the worker, and avoidable delays should be reduced to a minimum. There is nothing more irksome to a man who wants to work, but who is being constantly delayed through having to wait for tools or material, or who is stopped for an unnecessarily long time for some minor

machine repair or adjustment, or who has to wait for his work to be inspected. If an employer hopes to get the best out of his men, then he must serve them well in these respects. At the same time he must be prepared to pay fairly for all unavoidable delays.

Should occasion arise for any operation to be altered in order to save time, very great care should be taken in order not to give the workers the idea that it is done for the purpose of rate-cutting, and the time for the new operation should always be fixed so as to allow the operator to earn at least as much as he did before the alteration.

2.—What system of payment by results is most likely to promote a proper understanding between employers and Labour?

The most generally known systems are :—

1. Direct payment in hours or money for work done. That is the ordinary straight piecework system.
2. Bonus for time saved where basis wage is guaranteed.
3. Factory output bonus paid to all workers as a percentage on their wages.
4. The Ford system of flat rate for all workers where the wage paid is high, but which is in reality a variable piecework system inasmuch as the operator has to do the output called for, for that wage, or make room for someone else who can.

Now it does not, of course, follow that one particular system is the best for all classes and conditions of work. and therefore very great care should be taken in the selection of the system to be employed ; but whatever system is worked its success is bound to depend upon it being followed in the right spirit by both parties to the agreement, that is, masters and men, and in order to ensure this the one adopted must be just and equitable and also easily understood by the workers.

Dealing with the respective merits of the different systems as set down, probably the first—that is, straight piece-work—is not only the simplest, but the one least calculated to cause misunderstandings or disputes, inasmuch as the operator can calculate his earnings continuously as his work proceeds.

But, on the other hand, its success from the man's point of view must, of course, depend upon a continuous flow of work and an absence of delays outside his control. It also in many cases possesses another advantage, and that is that it gives some incentive to the operator to take care of his machine, so as to avoid delays for repairs with resultant loss to himself.

Experience teaches, however, that this does not apply equally to the small tools he uses, which he is often liable to use most extravagantly with a view to speeding up his output. In fact, so much so that in many works where a straight piece-work system is in vogue the employer is compelled to resort to the Truck Act

and to charge the man with tool breakages. This he is, of course, allowed to do only up to the actual cost of them to himself.

The system has the disadvantage of accentuating the difference between the fast and slow worker, and therefore tends to encourage restriction of output by the faster man to the level of the slower.

For this reason it is only suited to shops where large quantities of parts are continuously being produced, the quantities being such as to warrant the installation of special-purpose machines, or at least a large percentage of automatics.

There are sometimes worked variations of the straight piece-work system, such as the Taylor differential system, wherein the piece price varies with the number produced, the price being reduced when the output falls below a certain quantity in a stipulated time.

This, although offering a big incentive for the quick worker, resulting in cheap production, penalises the slow worker to a greater extent than in the straight system.

The other variation most usually met with is what is called the group piece system.

This can be profitably employed for any class of work where the men work in groups, such as capstan or semi-automatic sections, where a number of workers come under one tool setter, or for small sections, employing from ten to twenty men on the production of one or two simple parts.

Payment to each man is made by multiplying the group piece price by the total day rate wage of the individual, divided by the total day rate earnings of the group; thus the bonus earned by each individual is *pro rata* with his rate.

In the next case, namely, that of bonus paid for time saved:—

All the systems which come under this heading can be looked upon as a combination of the flat day rate and piece-work systems, since payment is made for the time spent, *plus* an incentive wage based upon the number of pieces produced in that time. In every case the day work rate is guaranteed by the employer, in return for which he retains a certain proportion of the money saved by the worker by increased production. The best-known systems of this kind are the Pittsburg, or what is usually called the Halsey system, in which a basis time is fixed, and of the value of the time saved half is paid to the worker, in addition to his guaranteed hourly rate, and half is retained by the employer. This halves the difference in bonus earned between the fast and slow worker.

Secondly, there is the Rowan system, in which the rate of bonus earned diminishes as the pieces produced in a given time increase. This system is probably the most generous to the slow worker, and also acts as a safeguard to the employer against loss on account of excessive times being given. It is therefore a good

system for use in a shop where quantities are not great and the work constantly changing.

In this case the bonus earned is arrived at by multiplying the product of the time taken and the time saved by the man's rate in pence per hour and dividing the result by the time allowed. Or, in other words, the bonus paid is the actual time taken multiplied by the man's rate in pence per hour multiplied by the fraction $\frac{\text{time saved}}{\text{time allowed}}$. This fraction must of necessity be less than one, since if it reached one it would mean that the work had to be done in no time. Thus it will be seen that the bonus paid can never equal the time rate of the worker, that is, he can never earn double time.

Rowan's idea in arriving at this system was that under no circumstances could even the quickest worker do twice as much work as an average worker, and if a price were set where a man could earn double time, then it was set too high; both of which ideas experience teaches us to be entirely wrong.

Expressed as a formula, if

a = time allowed, say 24
b = time taken, say 16
c = time saved, say 8
d = rate in pence per hour, say ... 12

Then $\frac{b \times c \times d}{a}$ equals hours,

$\frac{16 \times 8 \times 12}{24}$ equals 64 pence.

Thus the wages of the man would be 16 hours at 1s. equals 16s. *plus* 5s. 4d. bonus.

Thirdly, the Gantt system, under which the flat rate is guaranteed to the worker, but where the work is done in less than the basis time. It works practically as a straight piecework system.

A basis time is fixed for the work and a definite bonus paid provided the stipulated number of pieces are done during the time allowed, the whole basis time *plus* bonus going to the worker no matter how quickly he gets through the work.

Thus the basis time allowed for the piece might be five minutes, and the bonus rate fixed at $33\frac{1}{3}$ per cent.; then if 300 pieces had to be completed, provided these are got through in the time allowed (in this case twenty-five hours), the bonus paid would be $33\frac{1}{3}$ per cent., and if his hourly rate be 1s. the price paid for the 300 pieces would be 25s. *plus* 8s. 4d. bonus, or 33s. 4d., and the worker would receive this sum even if he completed the work in half the time. Thus it will be seen that under this system whereas the slow worker may earn no bonus at all, the earnings of the fast

worker increase very rapidly indeed once he has got level with the basis time.

Basis time (hourly rate plus $\frac{\text{hourly rate}}{3}$).

There are many other systems, such as the Cardullo diminishing system, similar to the Rowan system, with the addition of a time constant.

The standard time system similar to the Gantt system, but where two different rates are introduced according to whether basis time is taken or not.

The Emmerson system, where the bonus rises on a fixed scale, according to the efficiency of the worker, which is arrived at according to the number of pieces he does as compared with 100 in a given time, and many others designed to suit special conditions.

Now whatever system is adopted it is clear that the slow worker must be penalised to some extent. This, of course, is only right, but all have got to live, and one of the fundamental principles of Trade Unionism is to look after the slow or average man, and it is perhaps therefore only natural that the fast worker should adjust his earnings to within a reasonable amount of his less fortunate fellow. This being so, it is evident that the most successful system is that which gives a fair wage to the average man with sufficient incentive to enable him to earn at least a reasonable bonus and at the same time to enable the fast man to keep up his output as much as he can by the added incentive of a larger bonus, but one which does not increase too rapidly.

Of all the systems outlined, probably the Rowan most nearly meets this condition; but in this, unfortunately, the added incentive for the larger output falls off too rapidly, and the ideal would seem to be some form of compromise between this and the Halsey system.

Of the Ford system little need be said at this juncture. No doubt your discussion will bring out many points concerning it, but the main features are that the incentive is the fear of the sack, and it must certainly not be good for the fast worker who is anxious to do more and earn more, but whose energies are restricted for him by the rate of flow of work.

It is only natural that the employer should look for the highest possible machine hour output and also man hour output, as it is only by keeping these well up that he can keep his establishment charges down to a reasonable figure, but at the same time he must be fair and reasonable and not too grasping. He cannot expect the best from his men unless they are able to reap a fair reward for their labours, and he must not put upon his men the whole onus of that high output, but must himself shoulder the responsi-

bility of providing all possible facilities for a high-level production, and he should see to it that his work is so laid out and tooled up as to enable the average worker who has the will to work to produce the maximum possible amount of work without calling for a high degree of skill.

To gain this end he must see to it that care and attention is given to all the auxiliary branches of manufacture, such as jig and tool and cutter design. The selection of the most convenient type of machine tool for the work to be done. A good and efficient machine maintenance department. An efficient progress department. A clean, well-lit, and well-ventilated shop, and, above all, he must do all in his power to encourage *esprit de corps* amongst his workers by looking after their physical and social welfare and remembering that his men, like himself, are human beings.

Discussion on Mr. Rawlings' Paper entitled "Features of Machine Tools that make for Increased Production."

MR. WEATHERLEY (Member), in introducing the discussion, said that he would like to thank Mr. Rawlings for his excellent paper. He would like to have seen a wider range of machines shown, particularly with regard to radial drills. At a recent exhibition there was an example of an improved electrically driven radial with a simple direct drive with a particularly easy control. It seemed rather a pity that the largest machine tool makers in this country should allow other countries to bring forward the really new ideas, as in the case referred to.

With regard to milling machines, no one who visited the last Machine Tool Exhibition could help but recognise that machine tool makers had made wonderful improvements, but some of the improvement illustrated in the paper was not in evidence at the Exhibition. He referred to the use of two or more over arms to secure additional rigidity. This idea had been practised for a long time, but he felt that if one had to copy foreign machine tools one could not do better than copy the latest design of a popular American milling machine. The arm on this type of machine was not only much more rigid, but was also more convenient for the attachment of fixtures, etc.

Another point upon which he had often wished for enlightenment was why the big machine tool makers in this country had never produced a really sensitive tool room lathe. There were many points on these machines that tended to improve production, but one had to go outside this country to obtain such a machine.

Then there was the question of grinding machines and the variation of opinion regarding the moving head *versus* the movable work-table. In his opinion one of the main points to consider in this connection was the variation of weights between the centres. It was well known that metal would spread, and if one put a light piece between centres and then the next job was a heavy piece, the wear on the slides would be on two different faces entirely owing to the metal spreading. He (Mr. Weatherley) thought that very few people recognised this point in discussing the question of the moving head *versus* the moving table.

MR. RAWLINGS, in reply to Mr Weatherley, said that the whole

point of the paper was to deal with features that made for increased production irrespective of the particular make of machine. Assuming that any given feature tended to improve production, he had dealt with it without going into the question as to whether it was the best or not the best on the market. With regard to the electric control of radial drilling machines, for instance, this had disadvantages as well as advantages, and the fact remained that for ordinary work in this country centralised control was a feature that both improved and increased production. Thus the question as to whether it was better than any other type of control did not arise.

With regard to the travelling table on grinding machines, it must be admitted that the respective merits of the two types were governed largely by the size of the machine. On certain grinding machines built by the Churchill Machine Tool Co., for instance, the head travelled and the table remained stationary, but this was only on the very large-sized machines. On smaller sizes the travelling table maintained greater accuracy because, relatively speaking, there were larger wearing surfaces.

MR. BUTLER, in the Chair, said that he would like to make one or two remarks at that point. He very much appreciated several of Mr. Weatherley's remarks, and he thought Mr. Rawlings' reply was beside the point. Perhaps it was applicable as far as Mr. Rawlings was concerned, but we were here to compare the constructional features of machines made in this country with those made abroad. British machine tool makers should be capable of supplying features that could be obtained in foreign-made machines, and thus we had every reason, as an Institution, for illustrating machines made in this country or any special type of machine for the purpose of comparing it with any other machines on the market. The practice of illustrating a particular make of machine had sometimes been criticised. As an Institution, we were not concerned with who made the machines or whether the illustration partook slightly of the nature of an advertisement. We were interested in comparing what we could obtain from British manufacturers or any other manufacturers in foreign countries, and Mr. Weatherley had done what we all wished to do in pointing out the advantages of other machines against those illustrated in the paper.

While on this subject there was another feature of American machines particularly which was of interest, *i.e.*, automatic lubrication. If one went round a machine shop, as we did occasionally, and one watched a man fiddling about with an oil can, it was surprising how long he could spend on lubricating the machine if he did it thoroughly. Compare that with the very simple lubrication on, say, a Milwaukee milling machine, where the only operation was to tip a quart of oil into the tank. This feature

might be difficult to incorporate in the larger and more complicated types of machine tools, but it was one worthy of consideration. In fact, it was almost as important as centralised control, although it had received much less attention up to the present.

MR. PATTINSON (Member) said that Mr. Rawlings' paper was one of the most interesting that he had had the pleasure of listening to. He thought that the author had undoubtedly given much time and study to the preparation of the paper, and he was of the opinion that he had succeeded very well in suppressing the element of advertisement.

Referring to one or two questions raised in the paper, he was very interested in a remark made that by substituting ball bearings in a certain type of machine it would be possible to increase the output of the machine 60 per cent. He was tempted to wonder whether the operator had himself been fitted with ball races, as the percentage increase struck him as being extraordinarily high.

He quite agreed with the Chairman's remarks regarding lubrication systems. In almost any machine shop this was a matter which should receive attention. It was quite common to see a main journal lubricated by means of a little fiddling pipe with about $\frac{1}{8}$in. bore. Imagine what was bound to happen with a journal that was probably a very good fit. The point was certainly very important.

Another matter which should provide food for thought for machine tool makers was the type of pump that was fitted. We all remembered the simple centrifugal pumps of our apprenticeship days, and we had other antique fittings that we should like to see in a museum.

He was glad to learn from Mr. Rawlings that there were signs of a real revival in the British machine tool design and construction. In his opinion, this was long overdue. He had seen machines at exhibitions which were supposed to give a good output, but in the shops it was necessary to bolster them up in different places to get them to stand up to a heavy cut.

An interesting tool was that shown in the attachment for slotting a square hole in a shaft. If he remembered rightly, the illustration showed the shaft supported between a chuck and a centre. He was rather dubious about the quality of the finish that would be obtained in this way, as in his experience in slotting or broaching he had always found that the nearer the hole the steady or support could be located, the better the shearing effect obtained and, therefore, the quality of the finish.

Another important point was the relationship between the first cost of machine tools and the ultimate upkeep. Many times he had seen workmanship on new machine tools that was really a disgrace to any manufacturer. The result was that after the

machines had been in use for two or three months the services of the millwright were required, and in his experience some of these machines, by the time they were in really good order, were worth their weight in gold according to the money spent on them. In conclusion Mr. Pattinson said he wished to thank Mr. Rawlings most heartily for his excellent paper and to give him every credit for the trouble he had taken.

Mr. Rawlings, in reply to Mr. Pattinson, said that he regretted he had not made himself clear with regard to the 60 per cent. increase in power transmission efficiency. The 60 per cent. increase did not apply to the output, but to the reduction in the power absorbed in the transmission. With regard to centrifugal pumps for distributing lubricant or coolant, there was no doubt considerable field for experiment in the improvement of these fittings, but at the same time the centrifugal pump had the advantage that it did not easily clog.

With regard to the maintenance of machine tools, there was no doubt that many people were tempted to buy a low-grade machine tool simply because it was cheap. They gave very little attention to what amount of money would have to be spent upon it subsequently, and the net result was that, although the machine had a low first cost, it turned out to be much more expensive in the end than a really high-grade machine tool. He was of the opinion that the breakdowns mentioned were only experienced as a general rule on low-grade machines which someone had been permitted to buy on account of the low price.

With regard to the slotting attachment, there was no doubt about the point mentioned, but in the work illustrated the operation consisted in slotting a very small hole in an exceptionally large boring bar. It was not pretended that the operation was a production job; the attachment enabled special work to be handled quickly and economically.

Mr. Hancock (Associate Member) said he would like to thank Mr. Rawlings very much for his paper. With reference to the use of a variety of attachments on one machine, as mentioned in the paper by previous speakers, he felt perhaps he would introduce a more modern aspect to this subject. It seemed to him that on the machines illustrated in the paper the tendency was to crowd a variety of work on to the one machine. In his opinion, the best practice was to do the reverse when dealing with quantity production. That is, the machine should be stripped of unnecessary or universal equipment, as the small variety of work performed on the one machine in quantity production did not call for the use of this equipment. With anything like a large output it was much better to separate and classify machine operations according to different machine "set ups" than it was to perform a variety of operations on the one machine.

Another point which had always interested him was the low factor of rigidity which seemed to be adopted by some of the English machine tool makers. This last question may be connected with the previous one in so far as the design of machines for universal use is concerned. By increasing gear box feed and speed ranges, etc., the fundamental structure of the machine might suffer accordingly. He felt that the construction of a manufacturing machine, which would probably only deal with two or three different "set ups" per week, cutting similar material, allowed for a very much higher factor of rigidity and strength. Large cuts may be taken on this class of machine, less floor space occupied, and the machine need not be so expensive as the universal type. In connection with some of the radial drilling machines illustrated, it would seem that the addition of extra mechanical contrivances on the saddle had added to the overhung weight. Judging, however, by the appearance of the external construction of the vertical column, this seemed to be in no way increased to allow for this additional overhung weight. The possibility of the arm dropping when the drill was breaking through the hole seemed as though it might cause trouble.

Speaking of centralised control, he said, as a point of interest, that he had seen at the last Shipbuilding Exhibition a long lathe with a control lever on the saddle for controlling the clutch of the work spindle.

Regarding capstans, bar lathes, and centre lathes, there seemed to be a complete absence of vee beds on the machines illustrated. This did not seem correct, as the necessity for alignment between saddle, turrets, and work spindle had become much more apparent than of old, as the standard of accuracy demanded from these machines was high, especially on those machines which allowed for the use of fixtures. Referring to the grinding machines illustrated, he was still of the opinion that the work heads on both internal and external machines were inadequate for present-day demands.

He would suggest that the makers should supply a special head for use with fixtures more robust in construction, with a plain flanged spindle to accept fixtures. This method would reduce overhang of work from the bearings, and would give longer accurate life. He had not heard any mention made of automatic gauging or grinding machines, although there were many in use, and in his opinion they were absolutely necessary for accurate repetition work. He would also like to ask Mr. Rawlings if he knew of steady rests for grinding machines with automatic adjustment, as the hand method of adjustment still left a certain amount of skill on an otherwise unskilled peration.

Mr. Rawlings, replying, said, regarding the question of spring in machine tools, this came back to the matter of high-grade machines *versus* low-grade machines. According to one basis

adopted in buying machine tools, the weight was taken into account as giving some clue as to the amount of metal put into the machine. A comparison of English machines on this basis showed that they not only equalled but in the majority of cases they exceeded the weight of American machines of similar capacity.

MR. HANCOCK, continuing, said in connection with Mr. Rawlings' last remarks that he definitely wished to register his disapproval of this method of comparison, as it is the disposition of the metal according to possible stresses which was the important factor and not the total weight of the machine. In fact, he knew of a milling machine knee which, although lighter than a competitor, was more rigid under normal working stresses.

MR. RAWLINGS, in reply to Mr. Hancock, said that with regard to stopping the work spindle on a lathe from the saddle, this, of course, was only necessary on large machines. There was no question that automatic gauging was a very fine thing, and was undoubtedly a feature that improved and increased production. The vee beds on lathes and capstans was, of course, an old point, but there was one thing that should be noted, *i.e.*, that Langs were probably the largest lathe makers in the world devoted exclusively to lathes, and the fact that they were still in business might be taken as some evidence of the fact that the design adopted by them was satisfactory. The vee bed-flat bed controversy was rather too long to go into thoroughly at that point.

The question of fixtures on the spindles of grinding machines was certainly very important, and he would like to have shown a Churchill machine having a work head with a live spindle driven from the overhead countershaft and provided with a face plate on which fixtures could be bolted or work secured by means of a collet chuck.

In connection with the weight of the additional mechanism which had been included on the saddles of radial drilling machines, there were other points to be taken into account besides those mentioned by Mr. Hancock. For example, in the old days, when heat-treated gears were unknown, the mechanism was necessarily heavier for the same amount of power than at present, since with modern steels and suitable heat treatment gears could be made much smaller. In the same way shafts having loose splines or keys had to be made heavier for the same strength than the modern spindles having solid splines made in high tensile steel. New metals and new methods of construction had enabled machine tool makers to put a great many additional features in the saddle without increasing its weight. Moreover, the weight of the saddle on the radial arm was not such a big point as might appear in comparison with the stresses that were encountered when using a modern radial to the limits of its capacity with the saddle at the end of the arm.

MR. V. GARTSIDE (Member) said that he was rather of the same opinion as Mr. Weatherley, and that he would like to have seen a wider range of machines illustrated for purposes of comparison. As a machine tool maker, and in a sense a competitor of the Associated British Machine Tool Makers, Ltd., he felt bound to admit that the machines illustrated represented a great improvement on the product of ten or fifteen years ago. He felt, however, that there were many features that were not original that had been put forward in the paper as improvements, as, for instance, the double top arm milling machine referred to by Mr. Weatherley. Then with regard to the feed motion of manufacturing milling machines, he believed that he was one of the first to introduce automatic feed motion to the milling machine table of the type referred to in the paper. This was in the very early days of the war, and it was designed so that the operator simply moved a lever, when the table moved quickly up to the cutter, slowly traversed through the cut, and quickly returned and left the machine ready for the next piece. He had seen twelve machines of this type controlled by one operator, the machines being set so that they moved back one after the other. This design was followed by Pratt & Whitney, and later by makers in this country.

In conclusion, he certainly felt that if machines were dealt with, the author of the paper should gather together practically all known types of machines of the same class, irrespective of makers, so that the subject could be treated from every point of view. It was very difficult to stand up and criticise a paper of the type listened to without bringing in personalities.

THE CHAIRMAN interposed at this point, and said that he did not quite agree with the remarks of the last speaker. He had in mind the objects of the Institution, one of the chief of which was that we should pool our ideas as members. He was quite neutral, and was not a machine-tool maker in any way, and he felt bound to say that the spirit of advertisement, if it had entered at all, had come in very little indeed. He himself was either fortunate or unfortunate in being one of the few people responsible for obtaining papers for the session, and he always had in mind that the main point in connection with the paper was the discussion that followed it. Personally, he was prepared to ignore the question of advertisement, because he failed to see how we could compare machines reasonably without mentioning names. We did not hesitate to compare any particular machine with others produced by competitors, any more than we should hesitate to make comparisons if a representative came along to our works and wanted to sell us a machine. If any machine were not up to the standard required nowadays, the discussion was quite as likely to emphasise its demerits as it was to advertise its good qualities.

We were free here to compare our own ideas and experiences with a view to improving the products of the firms with which we were engaged, as well as to elevate the status of the production engineer, and the wider we could make the field of our investigation and our discussion the more useful would the Institution become.

MR. RAWLINGS said that, with regard to the remarks concerning the question of advertisement, if there had been any advertisement in the paper he was sorry that this element had entered into it. He had endeavoured, as far as possible, to avoid anything of the sort. Moreover, the firm he represented were hardly in the position of a single machine-tool maker, and, besides the question of advertisement, there was also the possibility of the reverse, in that members were quite free to pass any adverse criticism on any of the machines illustrated. The paper dealt with features that tended to increase production, but there was no claim that the features illustrated were the only ones of their class.

With regard to illustrating competitive makes of machines, this was not necessary, as makers of practically all types of machines were represented in the Association, and it was natural that he should deal with the machines with which he was most familiar.

The question as to whether the features were novel was hardly the point. The essential thing was that these features existed and that they did undoubtedly tend to increase production, and if the names of the makers of the machines were withheld the features mentioned might just as well be phantoms, as no one would be able to identify them or make use of them.

MR. GARTSIDE said that he thought he had not made his point quite clear. In raising the question of advertisement he was not referring so much to the discussion at the meeting as to the printed report of the proceedings, which would be published in the Institution *Journal*.

MR. BUTLER said that, before asking someone to propose a vote of thanks to Mr. Rawlings, he would like to point out that the Council would be pleased to receive suggestions for any papers that members might be able to give for the next session. He had already dealt at length with the type of paper required, but he might add that in any paper where the element of advertisement was likely to enter competitive manufacturers were invited to attend the meetings, and if they did not take advantage of this opportunity they themselves were to blame. At the same time he wished to assure members that the Council did all that they could to suppress the publicity side consistent with fulfilling the objects of the Institution. It would be agreed that they would have difficulty in keeping out names altogether.

The meeting concluded with a hearty vote of thanks to MR. RAWLINGS, proposed by MR. GERARD SMITH.

FUTURE MACHINE TOOLS.*

THE value of any forecast depends upon the ability to accumulate reliable data on past and present conditions, to note the effect of certain correlated factors in the past, and by proper deduction to conclude what the combined facts and conditions will produce in the future. With this in view a number of leaders in the machine tool industry of the United States have been asked to give their opinion of the future of the trade, and the numerous replies, whilst differing radically on some questions, point on the whole in much the same direction.

For an industry that has contributed so much towards the development of the manufacturing and business interests of the world, those responsible for the machine tool industry have not been financially rewarded commensurately with others. Large fortunes acquired quickly in the trade are unknown. At the same time development in machine tool design in the last 25 years has been rapid.

Development Dictated by Necessity.

In the past machine tool designers have been led somewhat by requirements of the users of machine tools giving them the best that ability and experience could produce to fulfil the conditions laid down. Tools that a few years ago were considered more or less special are now regarded as standard, and it is reasonable to expect a continuance of this transformation in the future.

The advent of high speed cutting tools calls for larger, stronger and more rigid machine tools, and since it may be surmised that cutting tools have not reached finality, machine tool design will have to keep pace with metallurgist development of cutting alloys. The more experience a machine tool manufacturer has with the performance of his product under the many and varying conditions prevailing, the more he is able to strengthen weaknesses, correct errors and generally improve his machine.

There has always been a necessary relation between design and development in the metal working industry and in machine tools. Nor have progressive machine tool builders waited for users to suggest improvements, but have foreseen most of the requirements for more strength, greater power, higher speeds and feeds, and more convenient operations, and have endeavoured to supply users accordingly. It is reasonable to predict that this condition will continue and that co-operative effort on the part of builders and users will grow stronger and closer in the future.

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* Abstract of an address delivered before the American Society of Mechanical Engineers by O. B. Iles, President, National Machine Tool Builders Association and International Machine Tool Co.

Automatics.

Leaders in the machine tool industry, as well as many of the largest users of machine tools, think that the demand for single-purpose machines, such as semi-automatics and automatics, will become more and more pronounced. If quantities are large enough this demand will be likely to lead to combination automatic machines doing multiple operations of milling, drilling, boring, turning, etc., on one machine. This is being tried in a small way, though the opinion of leading makers is divided on the extent to which machines of this type can be economically adopted. It is stated by some that combining operations leads to complications which lower production due to care of tools and breakdowns, but with more application of inventive and constructive skill who shall say that the machine tool designer will never overcome these troubles?

Standard Tools.

Whilst conditions point to the larger use of automatics and single purpose machines, there will always be a demand for the so-called standard machine tools, not only in small production shops, but in the larger plants. As automatics are further developed, the next decade will see a still further development in standard tools to meet the requirements of future cutting materials in strength and rigidity. Present designs will also be still further improved in simplicity of operation, accuracy, and particularly the maintenance of accuracy for the greatest length of time. The effect of labour conditions must also be taken into account especially as in the United States the number of men anxious and willing to do manual work is decreasing, whilst labour is becoming more and more costly. The machine tool engineer and designer should therefore be much in demand during the next decade by the manufacturer of all kinds of machinery and commodities.

Reducing Production Costs.

Hitherto the industries using machine tools have been growing and expanding. New lines have come into existence due to the demand for a higher standard of living, and during this period of expansion the methods of pioneers have prevailed with too little regard for waste in manufacture. It is the opinion of many thoughtful business men, however, that we have already entered into a period of most severe competition in manufacture, and this can only be met by modifying present methods to eliminate waste. Production costs must be reduced to the minimum by means of mass production, by the introduction of every refinement and device that will save time and labour, and by the elimination of all waste. Although during this period of competition the

machine tool builder will be in great demand for furnishing high production machine tools, the same competition will enter into the machine tool industry itself. Machine tool makers will be compelled to regard shop efficiency and management more closely than in the past, and the very latest equipment and methods must be employed by them as well as by their customers.

Difficulty of Mass Production.

Owing to conditions that have prevailed in the machine tool trade in the past and that still exist, it is difficult to see how it is possible ever to introduce mass production in the machine tool plant in the sense that it is generally understood and applied. The call for special features in the machines to meet specific requirements makes nearly every machine tool more or less a special machine and precludes large production. Further, the cost of carrying large stocks and the ever-present danger of obsolescence makes it too hazardous to manufacture for stock even the most standard machine tools in large quantities.

By what is termed the standard unit system, however, which is the present tendency of design, machine tool builders are enabled to manufacture certain parts and units in fair quantities. This means designing certain units so that they can be applied to more than one size or type of machine so that the units can be produced in larger quantities and the cost correspondingly reduced.

Organisation and Research.

Another important matter is the organisation of the industry as a whole. Whilst there will always be the small machine tool shop, there is evident advantage in combining small shops into a few large organisations to reduce distributing expense and other overhead charges. These organisations must, however, be built up without submerging or losing the advantages of individual responsibility and effort.

One of the problems before the National Machine Tool Builders Association is the reduction of the loss and waste caused by the periodic slack demand for machine tools. There is either a feast or a famine in the trade since users wait until they must have tools before they place their orders. To overcome this it is necessary in some way to educate the user to buy his plant more regularly and to forecast his requirements more accurately. Another problem is the disposition of used tools, and this calls for a plan whereby scrap will promptly go to the melting furnace and yet allow for tools that have residual value to be intelligently allotted to places where they can be of service. In demonstrating that money, time and effort are being wasted by the use of obsolete machines, machine tool makers must also be able to give sound advice on disposing of displaced machines.